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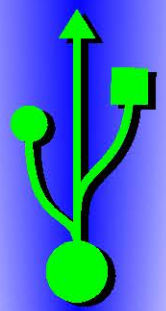
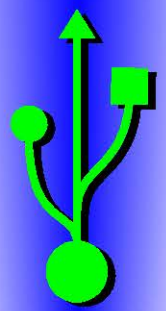


Developing USB device drivers on OS/2

By Markus Montkowski

NETL@B USB



Agenda

- OS/2 and USB
  - OS/2 USB Driver Stack
  - IDC interconnections
  - Device attachment
    - Class driver
    - HID Driver

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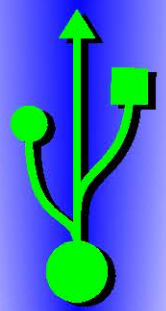

Hostcontrolers on OS/2

UHCI

OHCI

EHCI (USB 2.0) not yett

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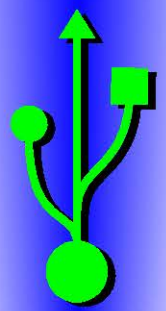

Drivers from IBM

Printer

Keyboard / Mouse

Audio

Modem

Mass Storage

Ethernet

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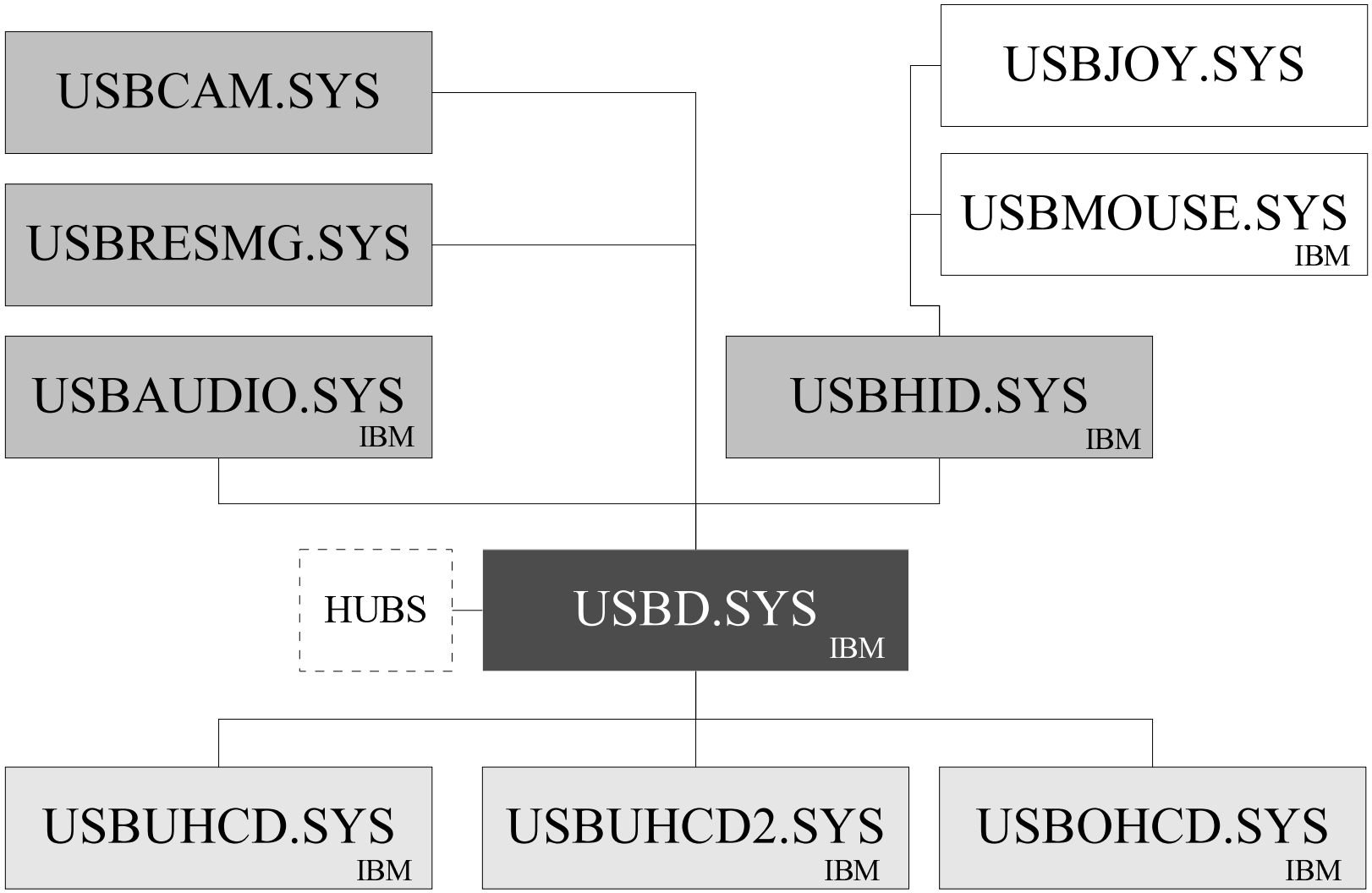
OS/2 USB Driver Stack



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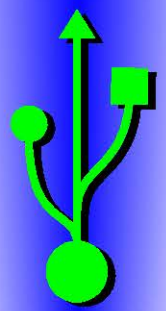

IDC Interconnections

- Attachment
  - To USBD during Init
  - To USBHID during InitComplete
- IDC between USBD and Host Driver
- IDC between USBD and Class Driver
- IDC betweed UDBHID and HID Driver

IDC between USBD and Host Drv.

HCD → USBD

Category Host

Register HCD

Category USBD

Process IRQ

Clear Stalled Pipe

USBD → HCD

Category Host

Accept IO

Cancel IO

Reset Host

IDC between USBD and Class Drv.

USBD ➔ Class

Category Class

- Process IRQ
- Check Service
- Detach Device

Class ➔ USBD

Category USBD

- Register Class
- Set Configuration
- Set Interface
- Accept IO
- Cancel IO

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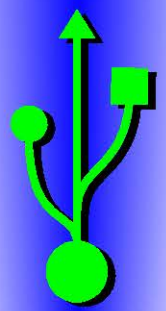

IDC betweed UDBHID and HID drv.

USBHID ➔ HID

Category Client

- Check Service
- Detach Device
- Process IRQ

HID ➔ USBHID

Category Class

- Accept IO
- Clear stalled dev.

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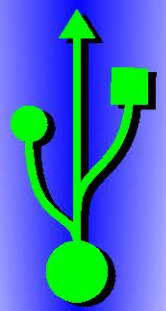

Device Attachment

UHCI Detects a change in the port status

The virtual RootHub dev. in UHCI signals HubStatusChanged to USBD

USBD Gets the new hub status and the status of the ports of the hub

USBD Gets the DeviceDescriptor

USBD Gets the length of the Configuration (max. 512 Bytes)

USBD Gets the Configuration

USBD looks for driver for this device

- **Hub devices are handled by USBD itself**
- **Enums all registered classdrivers and calls IDC USB_IDC_FUNCTION_CHKSERV for non Hub devices**

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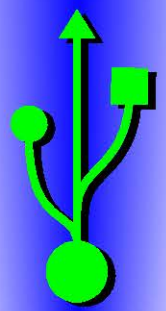


The IDC entry, heart of an USB driver

Receives USB_IDC_FUNCTION_CHKSERV

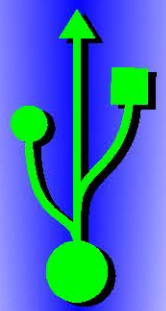
Receives USB_IDC_FUNCTION_DETDEV

Receives USB_IDC_FUNCTION_PRCIRQ

An IDC Sample function

```
void far IDCEntry (PRP_GENIOCTL pRP)
{
   USHORT status = pRP->rph.Status;
   pRP->rph.Status = 0;
   if (pRP->rph.Cmd != CMDGenIOCTL || !pRP->ParmPacket){
     pRP->rph.Status |= STERR | USB_IDC_PARMERR;
   }
   else if (pRP->Category != USB_IDC_CATEGORY_CLASS){
     pRP->rph.Status |= STERR | USB_IDC_WRONGCAT;
   }
   else
   {
      switch (pRP->Function)
      {
      case  USB_IDC_FUNCTION_PRCIRQ:              // 0x44
            pRP->rph.Status = status;
            IRQSwitch (pRP);
            break;
      case  USB_IDC_FUNCTION_CHKSERV:             // 0x45
            Service (pRP);
            break;
      case  USB_IDC_FUNCTION_DETDEV:              // 0x46
            Detach (pRP);
            break;
      default:
            pRP->rph.Status |= STERR | USB_IDC_WRONGFUNC;
      }
   }
   pRP->rph.Status |= STDON;
}
```

NETL@B USB



Checking for device Support

Class driver

- Check Vendor and Product ID
- Check Number of configurations
- Search for supported interface
- Check interface Needed Endpoints
- Set the Device Interface

HID device driver

- Check Usage (Page, Features ...)
- Get Report offsets
- Set Idle Time

Check Vendor/Product & configuration

```
void Service (PRP_GENIOCTL pRP_GENIOCTL)
{
  DeviceInfo      FAR   *pDevInfo;
   DeviceEndpoint FAR    *pEndPointD;
   USBSetConf       setConf;
   RP_GENIOCTL      rp;
   USHORT           VsrIndex, usInterface, usIFace;
   UCHAR            ucEndp;

  pDevInfo = ((USBCDServe FAR *)pRP_GENIOCTL->ParmPacket)->pDeviceInfo;
  if (pDevInfo->bConfigurationValue)
  {
    // already configured
    pRP_GENIOCTL->rph.Status = USB_IDC_RC_SERVREJCTD;
    return;
  }
  if ( pDevInfo->descriptor.idVendor  != VENDOR_HANDSPRING ||
       pDevInfo->descriptor.idProduct != PRODUCT_VISOR ||
       pDevInfo->descriptor.bcdDevice != DEVICE_RELEASE ||
       pDevInfo->descriptor.bNumConfigurations != 1)
  {
    pRP_GENIOCTL->rph.Status = USB_IDC_RC_SERVREJCTD;
    return;
  }

....
```

USB Device Info

```
typedef struct _DeviceInfo
{
   UCHAR              ctrlID;                // (00) controller ID
   UCHAR              deviceAddress;         // (01) USB device address
   UCHAR              bConfigurationValue;   // (02) USB device configuration
                                             //  value
   UCHAR              bInterfaceNumber;      // (03) 0 based index in
                                             //  interface array for this item
   UCHAR              lowSpeedDevice;        // (04) 0 for full speed device,
                                             //   nonzero - low speed device
   UCHAR              portNum;               // (05) port number to which
                                             //  device is attached
   USHORT             parentHubIndex;        // (06) index in hub table to
                                             //  parent hub,
                                             //  -1 for root hub device
   HDEVICE            rmDevHandle;           // (08) RM device handle
   SetupPacket        clearStalled;          // (12) setup packet for USBD
                                             //   internal use
   DeviceDescriptor   descriptor;            // (20) Device descriptor
   UCHAR              configurationData[MAX_CONFIG_LENGTH]; // (38) device
                                                    // configuration data
                                                    // (1062)

}  DeviceInfo;
```

USB Device Descriptor

```
Typedef struct _device_descriptor_
{
   UCHAR    bLength;              // (00) Size of descriptor in bytes
   UCHAR    bDescriptorType;      // (01) 0x01 - DEVICE Descriptor type
   USHORT   bcdUSB;               // (02) USB Specification Release Number
   UCHAR    bDeviceClass;         // (04) Class Code
   UCHAR    bDeviceSubClass;      // (05) SubClass Code
   UCHAR    bDeviceProtocol;      // (06) Protocol Code
   UCHAR    bMaxPacketSize0;      // (07) Maximum packet size for endpoint 0
   USHORT   idVendor;             // (08) Vendor ID
   USHORT   idProduct;            // (10) Product ID
   USHORT   bcdDevice;            // (12) Device release number
   UCHAR    iManufacturer;        // (14) Index of string descriptor
                                  //      describing manufacturer
   UCHAR    iProduct;             // (15) Index of string descriptor
                                  //      describing product
   UCHAR    iSerialNumber;        // (16) Index of string descriptor
                                  //      describing device's serial number
   UCHAR    bNumConfigurations;   // (17) Number of possible configurations
                                  // (18)
}  DeviceDescriptor;
```

Search for supported interface

```
...

  if (!(usIFace=SearchConfiguration((PUCHAR)&pDevInfo->configurationData,
                                    pDevInfo->descriptor.bNumConfigurations,
                                    INTERFACE_CLASS_VENDOR,
                                    INTERFACE_SUBCL_RESERVED,
                                    INTERFACE_PROTOCOL_RESERVED)))
  {
    pRP_GENIOCTL->rph.Status = USB_IDC_RC_SERVREJCTD;
    return;
  }

  pDevInfo->bConfigurationValue = LOBYTE(usInterface);

  //    Update global device list

  gVisors[VsrIndex].bConfValue = LOBYTE(usInterface);
  gVisors[VsrIndex].bInterface = HIBYTE(usInterface);

....
```

Check for needed endpoints

```
...
  for(ucEndp=1;ucEndp<=VISOR_NUM_BULKPIPES;ucEndp++) {
    pEndPointD = GetEndpointDPtr ( pDevInfo->configurationData,
                 pDevInfo->descriptor.bNumConfigurations, gVisors[VsrIndex].bConfValue,
                 0, ucEndp  | DEV_ENDPT_DIRIN);
    if ( pEndPointD &&
         ((pEndPointD->bmAttributes & DEV_ENDPT_ATTRMASK) == DEV_ENDPT_BULK))
    {
      gVisors[VsrIndex].bInEndpoint[ucEndp] = ucEndp  | DEV_ENDPT_BULK;
      gVisors[VsrIndex].wMaxInSize[ucEndp]  = pEndPointD->wMaxPacketSize;
    }
    else
    {
      pRP_GENIOCTL->rph.Status = USB_IDC_RC_SERVREJCTD;
      return;
    }
    pEndPointD = GetEndpointDPtr ( pDevInfo->configurationData,
                 pDevInfo->descriptor.bNumConfigurations, gVisors[VsrIndex].bConfValue,
                 0, ucEndp | DEV_ENDPT_DIROUT);
    if ( pEndPointD &&
         ((pEndPointD->bmAttributes & DEV_ENDPT_ATTRMASK) == DEV_ENDPT_BULK)) {
      gVisors[VsrIndex].bOutEndpoint[ucEndp] = ucEndp  | DEV_ENDPT_DIROUT;
      gVisors[VsrIndex].wMaxOutSize[ucEndp]  = pEndPointD->wMaxPacketSize;
    }
    else {
      pRP_GENIOCTL->rph.Status = USB_IDC_RC_SERVREJCTD;
      return;
    }
  }
...
```

Set device configuration

```
...
  gVisors[VsrIndex].pDeviceInfo = pDevInfo;
  gVisors[VsrIndex].active = TURNON;
  gNoOfVisors++;

  //   Set Visor Configuration. The request and the request's parameters
  //   are sent to the device in the setup packet.
  setConf.setConfiguration   = &gVisor.setPack;
  setConf.controllerId       = pDevInfo->ctrlID;
  setConf.deviceAddress      = pDevInfo->deviceAddress;
  setConf.classDriverDS      = GetDS();
  // desired configuration
  setConf.configurationValue = gVisors[VsrIndex].bConfValue;
  setConf.irqSwitchValue = VISOR_IRQ_SETCONF;
  setConf.category = USB_IDC_CATEGORY_CLASS;      // IRQ processor category
  setmem ((PSZ)&rp, 0, sizeof(rp));
  rp.rph.Cmd = CMDGenIOCTL;
  rp.Category = USB_IDC_CATEGORY_USBD;
  rp.Function = USB_IDC_FUNCTION_SETCONF;
  rp.ParmPacket = (PVOID)&setConf;

  USBCallIDC (gpUSBDIDC, gdsUSBDIDC, &rp);

  pRP_GENIOCTL->rph.Status = USB_IDC_RC_OK;
}
```

USB I/O Request Block

```
typedef struct _USBRb {
   UCHAR    controllerId;  // (00) controller ID
   UCHAR    deviceAddress; // (01) USB dev. address. Valid  [1,127], 0 for unconfigured
  UCHAR    endPointId;    // (02) device endpoint ID, valid  [0,15]
   UCHAR    status;        // (03) device status on request complete
   USHORT   flags;         // (04) Low order byte sets  transfer type,
                           //      High order byte gives packet details
   PUCHAR   buffer1;       // (06) Virtual address of data buffer
   USHORT   buffer1Length; // (10) Buffer length in bytes
   PUCHAR   buffer2;       // (12) Virtual address of second data buffer.
   USHORT   buffer2Length; // (16) Buffer length in bytes
   USHORT   serviceTime;   // (18) Required service frequency in ms. Valid [0,255].
   USHORT   maxPacketSize; // (20) maximum packet size to be used for this endpoint
   PUSBIDCEntry   usbIDC;  // (22) Address of IRQ routine to be called for this request
   USHORT   usbDS;         // (26) DS value for IRQ processing routine
   UCHAR    category;      // (28) callers category (used in IRQ extension calls)
   ULONG    requestData1;  // (29) data to be stored within request
   ULONG    requestData2;  // (33) data to be stored within request
   ULONG    requestData3;  // (37) data to be stored within request
   UCHAR    maxErrorCount; // (41) max. error count. Valid  [0,3]. 0 - no error limit.
   struct _USBRb  FAR *nextRb;  // (42) far pointer to chained request block, not used
   UCHAR    altInterface;  // (46) alt interface index support,
                           //      used when USRB_FLAGS_ALT_INTF is on
   // fields used for isohronous requests (USRB_FLAGS_DET_ISOHR is set in 'flags'
   UCHAR    isoFlags;      // (47) ishronous request flags (opening call, regular call,
                          //      last call, cancel call, info call)
   USHORT   isoFrameLength;// (48) # of bytes to be sent in a frame (only opening call)
   USHORT   isoBuffers;    // (50) max no of active buffers( only opening call)
                           // (52)
} USBRB;
```

Setup Packet

```
typedef struct _setup_Packet_{
   UCHAR       bmRequestType;   //  (00)  Characteristics of request
   UCHAR       bRequest;        //  (01)  Specific Request
   USHORT      wValue;          //  (02)  Word-sized field
                                //        (value depends on request)
   USHORT      wIndex;          //  (04)  typically Index or Offset
   USHORT      wLength;         //  (06)  Number of bytes to Transfer
}  SetupPacket;
```

```
D7: Data transfer direction
  0 = Host-to-device
  1 = Device-to-host
D6...5: Type
  0 = Standard
  1 = Class
  2 = Vendor
  3 = Reserved
D4...0: Recipient
  0 = Device
  1 = Interface
  2 = Endpoint
  3 = Other
  4...31 = Reserved
```

```
 0 GET_STATUS
 1 CLEAR_FEATURE
 2 Reserved for future use
 3 SET_FEATURE
 4 Reserved for future use
 5 SET_ADDRESS
 6 GET_DESCRIPTOR
 7 SET_DESCRIPTOR
 8 GET_CONFIGURATION
 9 SET_CONFIGURATION
10 GET_INTERFACE
11 SET_INTERFACE
12 SYNCH_FRAME
```

HID Device attachment

```
void JOYserv (RP_GENIOCTL FAR *pRP_GENIOCTL)
{
   USHORT                index, joyIndex;
   USBHIDServe     FAR *pServData;
   ReportItemData FAR *pItem;
   USHORT          usOffSet;
   // Check for free entry

   if (gNoOfJOYs < MAX_JOYS)
   {
      for (joyIndex = 0; joyIndex < MAX_JOYS; joyIndex++)
        if (!gJOY[joyIndex].active)
          break;
   }
   else
   {
      pRP_GENIOCTL->rph.Status = USB_IDC_RC_SERVREJCTD;
      return;
   }

   pServData = (USBHIDServe FAR *)pRP_GENIOCTL->ParmPacket;


...
```

USBHIDServe

```
typedef struct _USBHIDServe
{
  DeviceInfo FAR           *pDeviceInfo;    // far ptr to device data
  DeviceConfiguration FAR *devConf;         // far ptr to device config. data
  ReportItemData FAR       *itemData;       // ptr to report item data array
  ItemUsage FAR            *itemUsage;      // ptr to extra usage data array
  ItemDesignator FAR       *itemDesignator;// ptr to extra designator data array
  ItemString FAR           *itemString;     // ptr to extra string data array
  USHORT                   reportItemIndex;// starting report item index itemData
  USHORT                   versionFlags;    // specific version flags (HID drafts)
} USBHIDServe;
```

Check Usage

```
...

  index = pServData->reportItemIndex;
  while (index != LAST_INDEX)
  {
    pItem = pServData->itemData + index;

    if ( pItem->mainType == HID_REPORT_TAGS_MAIN_COLL &&
         pItem->itemFeatures.usagePage == HID_USAGE_PAGE_GDESKTOP &&
         pItem->localFeatures.usageMin == HID_GDESKTOP_USAGE_JOYSTICK &&
         pItem->localFeatures.usageMax == HID_GDESKTOP_USAGE_JOYSTICK )
    {
      break;
    }
    index = pItem->indexToNextItem;
  }

  if (index == LAST_INDEX)
  {
    // no Joystick
      pRP_GENIOCTL->rph.Status = USB_IDC_RC_SERVREJCTD;
      return;
  }

...
```

ReportItemData

```
typedef struct _RepItemData
{
  UCHAR           used;             // 00 nonzero if allocated
  UCHAR           interface;        // 01 interface index
  UCHAR           mainType;         // 02 item type - input, output,
                                    //    feature, collection
  USHORT          itemFlags;        // 03 item flags
  USHORT          parColIndex;      // 05 parent collection index
                                    //    (LAST_INDEX - no parent collection)
  USHORT          indexToNextItem;  // 07 index to next main item for this
                                    //    report
  // item features
  ItemFeatures    itemFeatures;     // 09

  // item local data
  LocalFeatures   localFeatures;    // 41
                                    // 59
}  ReportItemData;
```

ItemFeatures

```
typedef struct _item_features
{
  UCHAR         reportID;         // 09 report ID item belongs to
  ULONG         reportSize;       // 10 data size for this item
  ULONG         reportCount;      // 14 element count for current item
  USHORT        usagePage;        // 18 item's usage page
  LONG          logMin;           // 20 logical minimum for this item
  LONG          logMax;           // 24 logical maximum for this item
  LONG          phyMin;           // 28 physical value minimum
  LONG          phyMax;           // 32 physical value maximum
  ULONG         unit;             // 36 units of measurement
  UCHAR         unitExponent      // 40 exponent value
                                  // 41
}  ItemFeatures;
```

LocalFeatures

```
typedef  struct   _local_features
{
  // usage information
  USHORT          usagePage;         // 41 local (only this item) usage page
  USHORT          usageMin;          // 43 usage minimum
  USHORT          usageMax;          // 45 usage maximum
  USHORT          indexToUsageList; // 47
  // physical data references
  USHORT          designatorMin;     // 49
  USHORT          designatorMax;     // 51
  USHORT          indexToDesignator;// 53
  // string data references
  UCHAR           stringMin;         // 55
  UCHAR           stringMax;         // 56
  USHORT          indexToStrings;    // 57
                                     // 59
}  LocalFeatures;
```

Check length of report

```
...

  // Check if the total report Length of the device can be handled

  gJOY[joyIndex].ReportLength = 0;
  index = pServData->reportItemIndex;

  while (index != LAST_INDEX)
  {
    pItem = pServData->itemData + index;
    gJOY[joyIndex].ReportLength += pItem->itemFeatures.reportSize*
                                   pItem->itemFeatures.reportCount;
    index = pItem->indexToNextItem;
  }

  gJOY[joyIndex].ReportLength= (gJOY[joyIndex].ReportLength+BITS_IN_BYTE-1)
                               /BITS_IN_BYTE;

  if(gJOY[joyIndex].ReportLength > sizeof(gJOY[joyIndex].buffer))
  {
    // Report is to long
    pRP_GENIOCTL->rph.Status = USB_IDC_RC_SERVREJCTD;
    return;
  }
...
```

Parse for needed reports

```
...
  index = pServData->reportItemIndex;
  usOffSet = 0;
  gJOY[joyIndex].ulCapsAxes = 0;
  gJOY[joyIndex].ulCapsSliders = 0;
  setmem((PSZ)&gJOY[joyIndex].DevCapsJoy,0,sizeof(DEVCAPS));
  setmem((PSZ)&gJOY[joyIndex].joyState,0,sizeof(JOYSTATE));
  setmem((PSZ)&gJOY[joyIndex].AxeUnits,0,sizeof(JOYAXEUNIT)*JOYMAX_AXES);
  setmem((PSZ)&gJOY[joyIndex].Items,FULL_BYTE,sizeof(JOYITEM)*JOYMAXITEMS);
  while (index != LAST_INDEX){
    pItem = pServData->itemData + index;

    if ( pItem->mainType == HID_REPORT_TAGS_MAIN_INPUT &&
         pItem->itemFeatures.usagePage == HID_USAGE_PAGE_GDESKTOP) {
      if ( pItem->localFeatures.usageMin >= HID_GDESKTOP_USAGE_X &&
           pItem->localFeatures.usageMax <= HID_GDESKTOP_USAGE_Z ) {
        usOffSet = SetupXYZAxes(joyIndex, pItem, usOffSet);
        gJOY[joyIndex].inInterface = pItem->interface;
      }
      else
      { ... }
    else
    { ... }
      index = pItem->indexToNextItem;
   }
...
```

Last Check and SetIdleTime

```
  if ( (ULONG)0==gJOY[joyIndex].DevCapsJoy.ulButtons ||
       (ULONG)0==gJOY[joyIndex].DevCapsJoy.ulAxes) {
    // No Axes or No buttons
    pRP_GENIOCTL->rph.Status = USB_IDC_RC_SERVREJCTD;
    return;
  }
  gJOY[joyIndex].joyAddr = pServData->pDeviceInfo->deviceAddress;
  gJOY[joyIndex].controllerID = pServData->pDeviceInfo->ctrlID;
  gJOY[joyIndex].interruptPipeAddress =
  GetInterruptPipeAddr( pServData->pDeviceInfo->configurationData,
                        pServData->pDeviceInfo->descriptor.bNumConfigurations,
                        pServData->pDeviceInfo->bConfigurationValue,
                        gJOY[joyIndex].inInterface);
  gJOY[joyIndex].setITpack.bmRequestType = REQTYPE_TYPE_CLASS |
                                           REQTYPE_RECIPIENT_INTERFACE;
  gJOY[joyIndex].setITpack.bRequest = HID_REQUEST_SET_IDLE;
  gJOY[joyIndex].setITpack.wValue = 0x0000;  // all reports only if changed
  gJOY[joyIndex].setITpack.wIndex = gJOY[joyIndex].inInterface;
  gJOY[joyIndex].setITpack.wLength = NULL;
  gJOY[joyIndex].active = TURNON;
  gNoOfJOYs++;

  SetIdleTime (joyIndex, JOY_IRQ_STATUS_IDLESET);

  pRP_GENIOCTL->rph.Status = USB_IDC_RC_OK;
}
```

SetIdleTime

```
void SetIdleTime (USHORT joyIndex, USHORT kbdIRQstatus) {
  USBRB       rbHID;     // I/O request block
  RP_GENIOCTL rpHID;     // request packet

  rbHID.buffer1       = (PUCHAR)&gJOY[joyIndex].setITpack;
  rbHID.buffer1Length = sizeof(gJOY[joyIndex].setITpack);
  rbHID.buffer2       = NULL;
  rbHID.buffer2Length = NULL;
  rbHID.controllerId  = gJOY[joyIndex].controllerID;
  rbHID.deviceAddress = gJOY[joyIndex].joyAddr;
  rbHID.endPointId    = USB_DEFAULT_CTRL_ENDPT;
  rbHID.status        = 0; // not used
  rbHID.flags         = USRB_FLAGS_TTYPE_SETUP;
  rbHID.serviceTime   = USB_DEFAULT_SRV_INTV;
  rbHID.maxPacketSize = USB_DEFAULT_PKT_SIZE;
  rbHID.maxErrorCount = USB_MAX_ERROR_COUNT;
  rbHID.usbIDC        = (PUSBIDCEntry)JOYidc;    // Address of IRQ processor function
  rbHID.usbDS         = GetDS();
  rbHID.category      = USB_IDC_CATEGORY_CLIENT; // set client layer as IRQ processor
  rbHID.requestData1  = JOY_IRQ_STATUS_IDLESET;  // MAKEULONG (kbdIRQstatus,0);
  rbHID.requestData2  = MAKEULONG (joyIndex, 0);
  rbHID.requestData3  = 0;                       // not used
  setmem((PSZ)&rpHID, 0, sizeof(rpHID));
  rpHID.rph.Cmd    = CMDGenIOCTL;
  rpHID.Category   = USB_IDC_CATEGORY_CLASS;
  rpHID.Function   = USB_IDC_FUNCTION_ACCIO;
  rpHID.ParmPacket = (PVOID)&rbHID;

  USBCallIDC (gpHIDIDC, gdsHIDIDC, (RP_GENIOCTL FAR *)&rpHID);
}
```

Get Report Position

```
USHORT SetupPOVs(USHORT joyIndex, ReportItemData FAR *pItem, USHORT usOffset)
{
  USHORT usCount;
  usCount = 0;
  while( usCount < (USHORT)pItem->itemFeatures.reportCount &&
         gJOY[joyIndex].DevCapsJoy.ulPOVs < MAX_POVS)
  {
    gJOY[joyIndex].Items[JOYOFS_POV0+usCount].bReport    = pItem->itemFeatures.reportID;
    gJOY[joyIndex].Items[JOYOFS_POV0+usCount].usOffse    = usOffset;
    gJOY[joyIndex].Items[JOYOFS_POV0+usCount].usReportSize =
                                              (USHORT)pItem->itemFeatures.reportSize;
    gJOY[joyIndex].AxeUnits[JOYOFS_POV0+usCount].logMin = pItem->itemFeatures.logMin;
    gJOY[joyIndex].AxeUnits[JOYOFS_POV0+usCount].logMax = pItem->itemFeatures.logMax;
    gJOY[joyIndex].AxeUnits[JOYOFS_POV0+usCount].phyMin = pItem->itemFeatures.phyMin;
    gJOY[joyIndex].AxeUnits[JOYOFS_POV0+usCount].phyMax = pItem->itemFeatures.phyMax;
    gJOY[joyIndex].AxeUnits[JOYOFS_POV0+usCount].unit    = pItem->itemFeatures.unit;
    gJOY[joyIndex].AxeUnits[JOYOFS_POV0+usCount].unitExponent =
                                                  pItem->itemFeatures.unitExponent;
    gJOY[joyIndex].DevCapsJoy.ulPOVs++;
    usOffset += pItem->itemFeatures.reportSize;
    usCount++;
  }

  // Just in case the device has more than MAX_POVS Hatswitches
  usOffset += pItem->itemFeatures.reportSize  *
              (pItem->itemFeatures.reportCount- usCount);

  return usOffset;
}
```

Parse Report

```
void InterruptDataReceived (RP_GENIOCTL FAR *pRP_GENIOCTL)
{
  USBRB FAR *processedRB;
  BYTE      *pIntData;
  USHORT     joyIndex, i;
  LONG       lValue;
  processedRB = (USBRB FAR *)pRP_GENIOCTL->ParmPacket;
  joyIndex = LOUSHORT (processedRB->requestData2);

  if (gDevice)
    if (joyIndex != gJoyIndex)
      return;

  pIntData = (BYTE *)&gJOY[joyIndex].buffer;

  setmem((PSZ)&gJOY[joyIndex].joyState, 0, sizeof(JOYSTATE));
```

Parse Report cont.

```
...
  i=0;
  while(i< (USHORT)gJOY[joyIndex].DevCapsJoy.ulPOVs)
  {
    lValue = GetLogValue(joyIndex, JOYOFS_POV0+i);
    if(lValue)
    {
      if( gJOY[joyIndex].AxeUnits[JOYOFS_POV0+i].unit)
      {
        // Assume degrees and log 1 as top which is 0°
        lValue = (lValue -1)*
                 (gJOY[joyIndex].AxeUnits[JOYOFS_POV0+i].phyMax-
                  gJOY[joyIndex].AxeUnits[JOYOFS_POV0+i].phyMin)/
                (gJOY[joyIndex].AxeUnits[JOYOFS_POV0+i].logMax-
                 gJOY[joyIndex].AxeUnits[JOYOFS_POV0+i].logMin);
        // Report in hundredths of degrees
        if( gJOY[joyIndex].AxeUnits[JOYOFS_POV0+i].phyMax>=270 &&
            gJOY[joyIndex].AxeUnits[JOYOFS_POV0+i].phyMax<=360)
          lValue *=100;
      }
      else
      {
        // No Units so no physical values translate to degrees
        lValue = (lValue-1) * (36000/gJOY[joyIndex].AxeUnits[JOYOFS_POV0+i].logMax);
      }
    }
    else
    {
      lValue = 0x0000FFFF; // centered
    }
    gJOY[joyIndex].joyState.rgdwPOV[i] = lValue;
    i++;
  }
...
```

Item Usage, Designator and String

```
typedef struct _item_usage
{
   UCHAR           used;                  // nonzero if allocated
   USHORT          indexToNextUsageData;
   USHORT          usagePage;             // local (only this item) usage page
   USHORT          usageMin;              // usage minimum
   USHORT          usageMax;              // usage maximum
}  ItemUsage;

typedef struct _item_designator
{
   UCHAR           used;                        // nonzero if allocated
   USHORT          indexToNextDesignatorData;
   USHORT          designatorMin;               // designator minimum
   USHORT          designatorMax;               // designator maximum
}  ItemDesignator;

typedef struct _item_strings
{
   UCHAR           used;                    // nonzero if allocated
   USHORT          indexToNextStringData;
   UCHAR           stringMin;               // string minimum
   UCHAR           stringMax;               // string maximum
}  ItemString;
```

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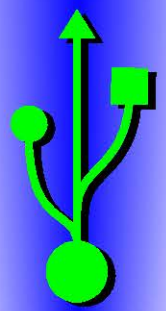

The Brain, the IRQ function

Gets called from the IDC function to process USB_IDC_FUNCTION_PRCIRQ

Each call to a USBCallIDC is followed by an IRQ which gets processed in it

Sample IRQ function

```
void JOYirq (RP_GENIOCTL FAR *pRP_GENIOCTL)
{
  USBRB FAR *processedRB;
  UCHAR oldCat;

  processedRB = (USBRB FAR *)pRP_GENIOCTL->ParmPacket;

  if(pRP_GENIOCTL->rph.Status != USB_IDC_RC_OK)
  {
    if (processedRB->status & USRB_STATUS_STALLED)
    {
      if( processedRB->requestData1!=JOY_IRQ_STATUS_STALLED )
      {
        oldCat=pRP_GENIOCTL->Category;
        JOYClearStalled(pRP_GENIOCTL);
        pRP_GENIOCTL->Category=oldCat;
      }
      return;
    }
    return;
  }

...
```

IRQ function cont.

```
...

  switch (processedRB->requestData1)
  {
    case JOY_IRQ_STATUS_IDLESET:
      pRP_GENIOCTL->rph.Status=STATUS_DONE;     //always ok
      ReadInterruptPipe (pRP_GENIOCTL);
      break;
    case JOY_IRQ_STATUS_DURATION:
      break;
    case JOY_IRQ_STATUS_INTPIPE:
      InterruptDataReceived (pRP_GENIOCTL);
      ReadInterruptPipe (pRP_GENIOCTL);
      break;
    case JOY_IRQ_STATUS_SETACK:
      break;
    case JOY_IRQ_STATUS_STALLED:
      ReadInterruptPipe (pRP_GENIOCTL);
      break;
    default:;
  }
}
```

ReadInterruptPipe

```
void ReadInterruptPipe (PRP_GENIOCTL pRP_GENIOCTL){
   USBRB FAR  *processedRB;
   USBRB       hcdReqBlock;
   RP_GENIOCTL rp_USBReq;
   USHORT      deviceIndex;

   processedRB = (USBRB FAR *)pRP_GENIOCTL->ParmPacket;
   deviceIndex = LOUSHORT(processedRB->requestData2);
   setmem((PSZ)gJOY[deviceIndex].buffer, UI_RESERV, sizeof(gJOY[deviceIndex].buffer));
   hcdReqBlock.controllerId  = processedRB->controllerId;
   hcdReqBlock.deviceAddress = processedRB->deviceAddress;             // use default address
   hcdReqBlock.endPointId    = gJOY[deviceIndex].interruptPipeAddress;
   hcdReqBlock.status        = 0;                                      // not used
   hcdReqBlock.flags         = USRB_FLAGS_TTYPE_IN | USRB_FLAGS_DET_INTRPT;
   if (!(processedRB->flags & USRB_FLAGS_DET_DTGGLEON))
     hcdReqBlock.flags |= USRB_FLAGS_DET_DTGGLEON;
   hcdReqBlock.buffer1       = (PUCHAR)gJOY[deviceIndex].buffer;
   hcdReqBlock.buffer1Length = gJOY[deviceIndex].ReportLength;
   hcdReqBlock.buffer2       = NULL;                                   // no additonal data to be sent to/from host
   hcdReqBlock.buffer2Length = 0;                                      // to complete this request
   hcdReqBlock.serviceTime   = USB_DEFAULT_SRV_INTV;
   hcdReqBlock.maxPacketSize = USB_DEFAULT_PKT_SIZE;
   hcdReqBlock.maxErrorCount = USB_MAX_ERROR_COUNT;
   hcdReqBlock.usbIDC        = (PUSBIDCEntry)JOYidc;                   // Address of IRQ proc.
   hcdReqBlock.usbDS         = GetDS();
   hcdReqBlock.category      = USB_IDC_CATEGORY_CLIENT;                // set USBD layer as IRQ processor
   hcdReqBlock.requestData1  = JOY_IRQ_STATUS_INTPIPE;
   hcdReqBlock.requestData2  = MAKEULONG(deviceIndex, 0);              // index in device table
   hcdReqBlock.requestData3  = 0;                                      // not used
   setmem((PSZ)&rp_USBReq, 0, sizeof(rp_USBReq));
   rp_USBReq.rph.Cmd    = CMDGenIOCTL;
   rp_USBReq.Category   = USB_IDC_CATEGORY_CLASS;
   rp_USBReq.Function   = USB_IDC_FUNCTION_ACCIO;
   rp_USBReq.ParmPacket = (PVOID)&hcdReqBlock;

   USBCallIDC (gpHIDIDC, gdsHIDIDC, (RP_GENIOCTL FAR *)&rp_USBReq);
}
```

GetLogValue

```
LONG GetLogValue( USHORT joyIndex, USHORT ItemOfs)
{
  LONG rc = 0;
  USHORT usOffset, usByteOfs, StartBit, usSize;
  BYTE     *pIntData, bRem;
  usOffset = gJOY[joyIndex].Items[ItemOfs].usOffset;
  usSize   = gJOY[joyIndex].Items[ItemOfs].usReportSize;
  pIntData = (BYTE *)&gJOY[joyIndex].buffer;

  // No proper index or Value to long
  if( (FULL_WORD==usOffset) || (usSize>32) )
    return rc;

  StartBit  = usOffset %8;
  usByteOfs = usOffset /8;

  //Check if in bounds of report
  if(usByteOfs>=gJOY[joyIndex].ReportLength)
    return rc;

  if(usSize>1)
  {
    if(!StartBit){
      // probably the easiest
      while(usSize>=8){
        rc *= 256;
        rc += pIntData[usByteOfs++];
        usSize-=8;
      }
      if(usSize){
        rc *= (2*usSize);
        bRem = pIntData[usByteOfs];
        bRem >>=(8-usSize);
        rc += bRem;
      }
    }
...
```

GetLogValue cont.

```
...
    else{
      if( (StartBit-usSize)<=0){
        // All bits are in this byte
        bRem = pIntData[usByteOfs];
        bRem &= gRightMask[StartBit];
        bRem >>= (8-usSize-StartBit);
        rc = bRem;
      }
      else
      {
        bRem = pIntData[usByteOfs++];
        bRem &=gRightMask[StartBit];
        rc = bRem;
        usSize -= (8-StartBit);
        while(usSize>=8){
          rc *= 256;
          rc += pIntData[usByteOfs++];
          usSize-=8;
        }
        if(usSize){
          rc *= (2*usSize);
          bRem = pIntData[usByteOfs];
          bRem >>=(8-usSize);
          rc += bRem;
        }
      }
    }
  }
  else
  {    // 1 Byte only
    bRem = pIntData[usByteOfs] & gBitMask[StartBit];
    bRem >>= (7-StartBit);
    rc = bRem;
  }
  return rc;
}
```

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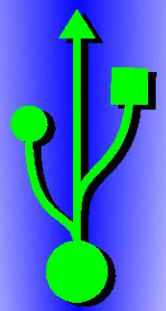

Useful information links

General info docs etc www.usb.org

USB device information www.linux-usb.org

Sources for many linux USB drivers
www.sourceforge.net

The OS/2 DDK with sources of USB drivers
service.boulder.ibm.com/ddk/